the effect of the different aspects of what may be called polarised cowls or terminals, *i.e.* cowls or terminals the action of which is different according to their position with regard to the direction of the wind. One of the most conspicuous is that of a cowl of the same shape as the torpedo air extractor now so much in use on railway carriages. From the numbers given, the apparatus is clearly much more effective when the wind crosses the opposed cones than when it passes along the cones and through the ring, and this difference of action is definitely characteristic of the two positions of the cowl.

Towards the end of the period of its labours the committee began to approach the question in more academic or philosophical fashion. Experiments with smoke were tried to see how cowls and terminals really acted. The committee was thus led to test the effect of successive variations of the number, size, position and arrangement of different modifying elements, such as a flange at the rim of the orifice or at a measured distance from it, a set of "feathers" arranged round the orifice and "louvre" bands or caps above it. A series of experiments to test the effect of the variation of a single element was carried out on single days and the results plotted in curves for the single varying elements. Here we have as results only galvanometer readings for different batteries, so to speak, but for batteries varying only in a single particular, and from such information effective inferences can be drawn about the action of the battery. These results afford the best material in the report for the scientific study of the action of cowls. It still remains only material, and requires working up with due regard to the theoretical considerations referred to. But some practical results follow directly. For example, a flange surrounding the orifice of the pipe diminishes the aëromotive force produced by wind passing over it, and if sufficiently extended practically annihilates the flow. It is not by any means impossible that an examination of these curves may lead to further investigation of the laws of flow through tubes under the action of passing wind. It is a subject which presents all the difficulties of the corresponding electrical problems, with some added in consequence of the inertia of the moving fluid, but it is of great practical as well as theoretical importance, and the report will have done good service if it attracts attention to the further study of the subject from this aspect.

One of the most amazing facts about the history of science in the last century is the little progress made in our knowledge of pneumatics compared with the advances in our knowledge of the flow of electricity, which still borrows its language for practical purposes from the older and now almost neglected study of the flow of fluids. The theoretical development of electricity can be attributed to Faraday's experimental investigation of the laws of electromagnetic induction. The flow of air along pipes in consequence of wind passing over the top may fairly be regarded as a case of pneumatic induction. The experiments of the cowl committee, if they have not succeeded in classifying these inductive effects into laws, have reopened the study of the subject, and at least give evidence that it is not the fulness of experimental knowledge that has dissuaded the intellects of the students of our laboratories from its investigation.

W. N. SHAW.

GOLD IN INDIA.

INDIAN gold is attracting the attention of the Geological Survey of India. In NATURE for May 9, 1901, we directed attention to Dr. F. H. Hatch's report on the Kolar gold-field in Mysore. We have now received reports on the gold-fields of Wainád, by Mr. H. H. Hayden and Dr. Hatch, and on some auriferous localities in north Coimbatore, by Mr. Hayden (*Mem.* Geol. Survey, India, vol. xxxiii. part ii. 1901.) These districts lie to the south of Mysore. The extraordinary discrepancy between reports made on various properties of Wainád by mining experts and the actual results subsequently obtained have justified independent investigations on the part of the Indian Government. It is recorded that in 1880 numerous companies, having an aggregate capital of more than four million pounds, were floated on the London market; of these only three companies retain their properties, and no work has been done for a number of years. The question to be solved was whether improved modern methods might render it possible to revive the gold-mining industry in the area. Dr. Hatch's report is, however, unfavourable. Dealing specially with two mines, he finds that ore does not occur in payable quantity, and he is unable to recommend further prospecting. Mr. Hayden gives an interesting historical sketch of the gold-mines, and describes in some detail the geological features of the district. The country-rock is in most cases biotite gneiss; this has been affected by a series of parallel fissures which run obliquely to the direction of the foliation, and in these fissures the vein-material was deposited. Pyrites proved to be the chief source of the gold, but the richer ore-bodies are small irregular patches, not of sufficient extent to be of material value.

Mr. Hayden remarks that there are few auriferous areas in India, poor as well as rich, that have not at some period or other been exploited by the natives; but the fact that gold was obtained in sufficient quantity to cover the expenses and leave a margin of profit, does not in itself justify the belief that a good margin of profit would be obtained if modern methods of working were adopted. Many of the reefs were probably mined by forced labour or by slaves. Thus one of the Wainád reefs, which was, perhaps, worked more extensively than any other, has given, from nearly 200 samples, an average yield of about two pennyweights of gold to the ton of ore. In Coimbatore there are numerous old native workings for gold, but they are, as a rule, small and unimportant, and the ore-bodies are either very thin or barren. Further prospecting, however, appears to be advisable in this district.

NOTES.

THE attendance of the Prince of Wales at the meeting of the Royal Society on Thursday last is an event which we have pleasure in recording. His Royal Highness was formally admitted as a Fellow of the Society, and remained throughout the meeting. At the close of the proceedings he was invited by the president to address the meeting, and in response he said:—"Mr. President, my lords and gentlemen,—It gives me very great pleasure to have been able to come here to-day and to be formally admitted as a Fellow of this ancient and distinguished society. But, as you conferred the honour of Fellowship upon me some eight years ago, I really ought to apologise for not having presented myself before. I can only say I am indeed proud that my name should be added to those on your illustrious roll, which has been inscribed by nearly every Sovereign since the reign of Charles II., and by all the most distinguished men of science since those days, such as Wren, Newton, Davy, Faraday, Darwin, and many others. I would wish to offer my sincere thanks to Sir William Crookes for his most interesting lecture, which I am sure we have all listened to with great pleasure. If I may be allowed to do so, I should like to congratulate him on his power of treating such an abstruse question (for I must confess that the title rather alarmed me) so as to make it intelligible and attractive to those who, like myself, unfortunately cannot lay claim to much scientific knowledge. But, while fully realising how far beyond my reach this knowledge lies, I can assure you of my hearty sympathy with that scientific study and research, which now, more than ever, has become so important an essential in our national life."

At the annual general meeting of the Royal Astronomical Society, to be held to-morrow, February 14, the Society's gold medal will be presented to Prof. J. C. Kapteyn, of Groningen, Holland, for his work in connection with the Cape Photographic Durchmusterung and his researches on stellar distribution and parallax. The Jackson-Gwilt (bronze) medal and gift will be presented to the Rev. Thos. D. Anderson, of Edinburgh, for his discovery of Nova Aurigæ and Nova Persei.

The first afternoon meeting of the Chemical Society will be held on Wednesday next (February 19) at 5.30 p.m. Among the papers to be read are two on "Enzyme Action," by Prof. Adrian Brown, of Birmingham, and by Dr. Horace Brown, F.R.S., and Mr. Glendinning, and one entitled "The Union of Hydrogen and Oxygen," by Mr. H. Brereton Baker.

We learn from *Science* that the Johns Hopkins University will celebrate its twenty-fifth anniversary on February 21 and 22, when President Remsen will be formally inaugurated. Dr. D. C. Gilman, president emeritus, will deliver a commemorative address on February 21, and President Remsen will give his inaugural address on the following day.

The fall of red dust described by Sir Edw. Fry in last week's Nature (p. 317) appears to have been observed over a wide area. Mr. F. H. Perry Coste sends us a cutting from the *Cornish Times* of February 8, in which it is stated that remarkable showers occurred over a large part of Cornwall during the latter part of January, the rain holding in suspension a fine dust, variously described as ranging from yellow or sandy-colour to whitish or brick-red. At Liskeard the deposit is spoken of as yellowy-red in colour; at Menheniot it had the appearance of brick-dust; at Calstock the deposit left by the rain was like fine yellow mud or sand; while, among other places in this neighbourhood, the dust attracted attention at Callington, Gunnislake and Altarnun.

The Toronto correspondent of the *Times* writes that the Canadian Government regard with much satisfaction Mr. Marconi's recent success in signalling across the Atlantic. We rather question whether the results as yet obtained justify the hopes which seem to have been raised for a speedy establishment of cheap telegraphic communication between Canada and the mother country. More reasonable is the idea of utilising the system to its full in order to assist navigation at the mouth of the St. Lawrence. Canadian commerce, it is pointed out, will greatly depend in the future on the development of the St. Lawrence route, and there can be no question that navigation of the Gulf of St. Lawrence and the coast of Newfoundand would be much aided by a system allowing for communication between ship and ship and ship and shore.

The Paris correspondent of the *Times* announces the death, at the age of seventy-two, of Mme. Clémence Royer, who first became known to the French reading public by her translation, in 1862, of Darwin's "Origin of Species." To this translation she prefixed what is regarded as one of the most famous essays in contemporary French thought. She was the author of "Le Bien et la Loi Morale" (1881) and of "La Constitution du Monde" (1900), and numerous original memoirs on archæology and anthropology. In 1895, MM. Berthelot, Aulard, Th. Ribot, Ch. Richet, Letourneau and Levasseur solicited for her the Cross of the Legion of Honour, alluding to her thus:—"Savante et philosophe d'une valeur rare c'est une des illustrations féminines de ce siécle." This decoration was not given her, however, until 1900, when the Minister of Education, M. Leygues, officially bestowed it at a banquet organised by Mme. Clémence Royer's Breton compatriots.

The death is announced of Mr. William Martindale, the well-known pharmacist. From an account of his career in the *Pharmaceutical Journal* we learn that Mr. Martindale was born near Carlisle in 1840. In conjunction with Dr. W. Westcott he produced the very successful work entitled "Extra Pharmacopœia," which is highly appreciated by both physicians and pharmacists. For ten years (1873–1882) he was a member of the Pharmaceutical Society's board of examiners for England and Wales. In 1889 he became a member of the Society's council, in 1898 he was elected treasurer of the Society, and the following year he became president. He was president of the British Pharmaceutical Conference on two separate occasions; he was also a member of the council of the Royal Botanic Society, and interested himself in a scheme for the improvement of botanical teaching in London. In addition, Mr. Martindale was a Fellow of the Chemical Society, the Linnean Society, and a member of the Sanitary Institute and the Society of Arts. His position as a prominent pharmacist was recently indicated by his appointment as a member of the Privy Council's poisons committee.

A short account of the results of the census of 1901 in France is given in *La Geographie* by V. Turquan. The population in each department is compared with the returns of 1801 and 1896, and the changes clearly shown by means of charts. It appears that between 1896 and 1901 twenty-eight departments show an increase averaging 25,200 each, if that of the Seine be included, or 16,000 if it be omitted, while fifty-nine departments show a decrease averaging 6000 each, a result indicating the movement of the rural population to the towns. The greatest per cent. increase is around Paris, in the departments of Nord and Pas de Calais, and along the shores of the Mediterranean; and the greatest decrease is in the basin of the Garonne, the department of Lot heading the list with a decrease of 6·1 per cent.

Dr. H. Fritsche, director of the Pekin Observatory, has published the results of his investigation of the daily period of the elements of terrestrial magnetism, for the winter and summer seasons, based upon Gauss's general theory, and the hourly observations of twenty-seven places comprised between latitudes 80° N. and 56° S. This is the fourth work by the same author on the determination of the magnetic elements. The observations used have been collected partly from original publications and partly from those contained in the German *Meteorologische Zeitschrift*. The means are calculated from *all* the observations, including days of magnetic disturbance. Dr. Fritsche gives a detailed explanation of the formulæ employed.

The current number of *Knowledge* contains an interesting note by Sir Samuel Wilks, F.R.S., on the history of Fahrenheit's thermometer, which, he states, owes its origin to the invention of a thermometer by Newton, described in the *Philosophical Transactions* for 1701. Newton's instrument was a tube filled with linseed oil, the starting-point being the temperature of the human body, which he called 12 (the duodecimal system being then in use); he divided the space between this and the freezing point into twelve parts, and stated that the boiling point would be about 30°. Fahrenheit, not finding the scale minute enough for his work in using Newton's instrument, first divided each degree into two parts and made it measure 24 instead of 12. Finding he could obtain a lower temperature than freezing by mixing ice and salt, he took this for his starting point, and counted 24 degrees up to body heat, making 8 freezing point and calling boiling water 53. Later on he divided each degree into four parts; it will be seen that if the last-mentioned numbers are multiplied by four, we have the thermometer which is now in use.

A YEAR ago the Scientia Club of Paris gave a dinner in honour of Prof. E. J. Marey, the eminent French physiologist, whose work has disentangled the intricacies of many animal motions. At the close of the banquet, Prof. Marey's numerous colleagues, friends and pupils expressed the desire to give tangible testimony of their admiration of his scientific achievements, and eventually it was decided to present him with a commemorative medal. This souvenir was engraved by Dr. Paul Richer, and the accompanying illustrations from *La Nature* show its remarkably fine character. The presentation was made to Prof. Marey at a meeting held at the Collège de France on January 19. M. Leygues, Minister of Public Instruction and Fine Arts, occupied the chair, and a large number of eminent men of science and other representatives of learning were present. M. Gaston Paris, administrator of the College, gave expression to the feelings of those who had combined to show their admiration of Prof. Marey's contributions to the study of physiological actions; and he was followed by M. Franck, one of Prof. Marey's old pupils, who described the work of his master. M. Chaveau spoke as an old and close friend, and M. Leygues, after referring to the chief characteristics of Prof. Marey's researches, remarked in conclusion:—"Je prie Monsieur Marey, au nom du gouvernement de la République, dont je suis ici le représentant, d'agréer l'hommage de sa reconnaissance et de sa respectueuse admiration." Letters and telegrams of congratulation were received from many physiologists unable to be present at the meeting; and Prof. Marey replied in appropriate terms of thanks to the numerous expressions of regard of which the medal which has been presented to him is a token.

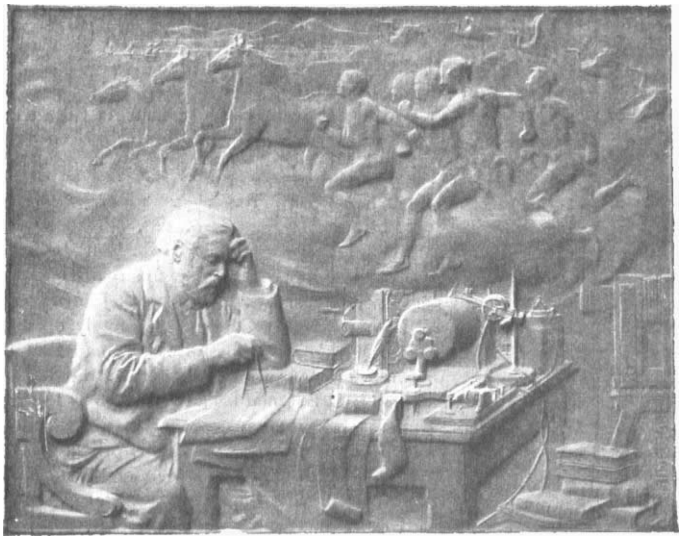

FIG. 1.—M. Marey in his laboratory. Reverse of medal.

REFERRING to the experiment described by Mr. F. Hodson in last week's NATURE (p. 319), Mr. J. D. T. Morris writes from the East London Technical College to say that it is possible to produce both kinds of electrification in sealing-wax by rubbing it with silk. As with the glass rubbed with fur, gentle rubbing produces positive electrification and more vigorous rubbing produces negative electrification. The change is probably due to difference of temperature of the surface of the material used, caused by the varying amount of energy used in the friction.

A NEW monthly journal has just been started at Florence, bearing the title *La nuova Rassegna tecnica internazionale.* It contains abstracts of important papers on engineering and applied science, a summary of current literature in this region, both Italian and foreign, notices of books, of exhibitions, prizes, vacant appointments and congresses. In the present number, projected railways and automobiles receive a fair share of attention. The *Rassegna* should be useful in giving a synopsis of the most important topics of the day in connection with practical engineering.

SOME interesting details relative to trials with secondary batteries for electric traction on branch lines of railway in Germany are given in the issue of the *Centralblatt für Accumulatoren- und Elementenkunde* for December 15, 1901. These trials were instituted in 1898, after a special form of Planté cell had been devised for the particular work. The negative plates of the cells were found in actual use to have a shorter life than the positive plates, and it was necessary to take these out and to repaste them after they had done duty for 30,000–40,000 km. The batteries were carried under the seats of the carriages, and weighed fifteen tons; while the complete weight of a carriage, with its motor equipment and complement of 112 passengers, was fifty-three tons. Two of these larger carriages and two smaller ones, with accommodation for sixty-eight passengers, were built, and were regularly run on branch lines connecting the following towns in the Palatinate:—Ludwigshafen Neustadt, Worms, Schifferstadt, Landau and Amweiler. The normal speed at which these carriages were run was one of 45 km. per hour. The total cost of the larger carriages was 2750*l.*, the electrical equipment representing 1625*l.* of this total. The running costs are stated to have been 27·5 pfg. per car kilometre when generating charges were included, and only 21 pfg. when the batteries were charged at the central lighting station—presumably in Ludwigshafen. The corresponding charge for

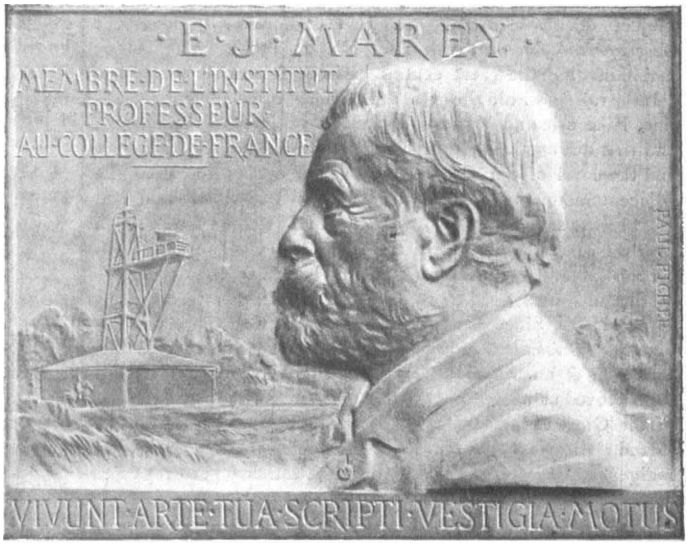

FIG. 2.—M. Marey, Member of the Institute of France. Face of medal.

steam traction is stated to be 28 pfg. In the light of these trials the use of accumulator traction on short branch lines of railway, is considered to be practicable and economical.

PROF. HOLBORN, of the Reichsanstalt, Berlin, has designed a new form of electric resistance laboratory furnace, which permits temperatures up to 1500° C. to be attained with ease by use of the ordinary 110-volt electric supply. These furnaces are made in two forms, the first being adapted for heating crucibles and the second for heating tubes 44 cm. in length. Both forms of furnace are alike in principle, the electric current being conducted through a resistance coil of platinum or nickel wire, wound round a thin porcelain tube or cylinder. The crucible or substance to be heated is placed within this latter, and the space between the outer side of the coil and the containing vessel is packed with asbestos or powdered quartz. Using nickel, the temperature of the furnace cannot be raised above 1000° C. without damage to the coil, but with platinum it is possible to attain a temperature of 1500° C. with a current of 14 amperes and 110 volts. It is necessary in the use of these furnaces to include a resistance in the circuit and to use only one-half of the maximum current when the heating is first commenced. The use of exterior resistance enables the temperature of the furnace to be regulated with ease, within somewhat narrow limits. Further advantages claimed for these furnaces are—that the separate portions are replaceable when worn out, that the heating spirals can be easily removed and changed to suit the special temperatures required, and that with the tube form of furnace, the heating of the substance can be carried on in the absence of air and in the presence of any desired gas or gaseous mixture. It would be interesting to know whether any attempts have been made to apply electrical resistance heating, to organic combustion work. The usual type of gas-heated combustion furnace is capable of improvement, and the substitution of electricity for gas would bring with it some notable advantages. In localities where the day supply of electricity is at reduced rates, this application is worthy of attention.

THE climate and artesian waters of Australia form the subject of an essay by Mr. J. P. Thomson (Queensland *Geographical Journal*, vol. xvii. No. 2, 1902). The author maintains that the great central basin of Australia, as well as certain valleys within the area, are hemmed in by ancient crystalline, Palæozoic and Mesozoic rocks of an impervious character; and that during the Cretaceous period the valleys were filled up and the level of the central basin raised by detritus from the adjacent mountain ranges. Thus extensive beds of sand and gravel were spread out, and these were followed by a deposition over the central area of fine clays and shales. The clays to a certain extent seal up the water which is held in the Cretaceous sands and gravels, and thereby a good source of artesian water is provided. Since his paper was printed, Mr. Thomson announces (*Brisbane Telegraph*, December 28, 1901) that the existence of an abundant supply of good drinking water has been proved at a depth of 30 feet in the Eucla district north of the Great Australian Bight. This discovery indicates that inland settlements may be feasible in tracts which furnish good indigenous bush feed for cattle, but have hitherto been regarded as drought-stricken.

WE have received a copy of a paper by Mr. P. Frandsen, published in the *Proceedings* of the American Academy (vol. xxxvii. No. 8), on the effects of directive stimuli on slugs. It appears that, as the result of previous experiments, it has been stated that when slugs are placed on an inclined plane of glass, some move in an upward and others in a downward direction. One of the objects of the author's investigations was to test the truth of this statement, and, if true, to find a reason for the diversity of habit.

IN his presidential address to the Edinburgh Field Naturalists' and Microscopical Society, which appears in the *Transactions* for 1901, Mr. W. C. Crawford gives an interesting account of the ant-colonies shown in the Paris Exhibition, and suggests that similar exhibits might with advantage be introduced into this country. In the same volume, Mr. T. Speedy gives some interesting notes on the life-history of the badger, while Mr. A. A. Pinkerton discourses on the habits of the mole. In the course of his paper the former gentleman states that it is a common belief that young badgers do not suckle till a considerable time after birth.

SPECIAL interest is attached to Mr. R. Quick's paper on "Human Bone Instruments" in *The Reliquary and Illustrated Archaeologist* (vol. viii. January, 1902, p. 28), as the figures which illustrate it are from specimens in the Horniman Museum. It will be in the memory of our readers that this really remarkable museum was given last year by Mr. Frederick John Horniman, M.P., to the London County Council to be freely open to the public. In Mr. Quick's somewhat discursive paper an interesting series of three Tibetan drums is figured; the first is made of two human calvaria fastened back to back so as to form a sort of hourglass-shaped instrument, two knotted strings constituting the clappers. Another specimen is a brass model of two calvaria, and the third is a wooden one yet more conventionalised. Trumpets made from the thighbones of lamas and a lama's skull cap used as a drinking vessel are also illustrated.

A GOOD deal of untrustworthy theorising has been applied to textile markings found on the pottery of primitive peoples; Mr. W. H. Holmes has a careful, discriminating paper on this subject in the *American Anthropologist* (iii. 1901, p. 397). He finds pottery so marked can be divided into five classes: (1) Impressions from the surface of rigid forms, such as baskets; (2) Impressions of fabrics of a pliable nature, such as cloths and nets; (3) Impressions from woven textures used over the hand or over some suitable modelling implement; (4) Impressions of cords wrapped about modelling paddles or rocking tools; (5) Impressions of bits of cords or other textile units, singly or in groups, applied for ornament only and so arranged as to give textile-like patterns. In addition we have a large class of impressions and markings in which textile effects are mechanically imitated. Those who are interested in our own prehistoric pottery should study Mr. Holmes' paper.

A NEW volume of *The Geographical Journal*, containing the numbers published in the latter half of last year, has been received. Among the papers in the volume we notice the following as of wide interest:—Sand-waves in tidal currents, by Dr. Vaughan Cornish; the Antarctic voyage of the *Belgica* during the years 1897, 1898 and 1899, by Mr. H. Arçtowski; the anthropogeography of Argentina, by Dr. F. P. Moreno; the National Antarctic Expedition; and the lake-level of the Victoria Nyanza, by Mr. E. G. Ravenstein. There are in addition a number of papers on explorations, accompanied by maps, and the usual monthly record of progress in the knowledge of geography.

MESSRS. SANDERS AND CROWHURST have sent us for examination a number of brilliant lantern slides of birds and other zoological subjects. Photography has been a helpful handmaid to many branches of science, but none of its performances are more widely appreciated than those in the field of natural history. Drawings of animals may have artistic merit, but they do not inspire the feeling of life which is conveyed by good photographs of objects in their natural surroundings. The lantern slides sent by Messrs. Sanders and Crowhurst are from photographs of birds, nests, eggs and young and other living animals taken by Mr. Oliver G. Pike. To lecturers on natural history such true pictures of living creatures must be invaluable, and no better source of encouragement to study nature could be desired. By the side of such beautiful photographic pictures as are now available for projection upon a screen or for the illustration of books, the drawings which did duty in natural history instruction seem but a vain show. Messrs. Sanders and Crowhurst send us with their slides an ingenious arrangement for viewing lantern slides under a low magnifying power. The arrangement, though simple, is very effective, and a pleasant half hour can be passed by using it to look at lantern slides.

THE additions to the Zoological Society's Gardens during the past week include a Greater Vasa Parrot (*Coracopsis vasa*) from Madagascar, presented by Lady Amherst of Hackney; a Black-footed Penguin (*Spheniscus demersus*) from South Africa, presented by Lieut. F. J. Mosely; a Black-headed Gull (*Larus ridibundus*), European, presented by Miss M. Hall; a Bataleur Eagle (*Helotarsus ecaudatus*) from Lagos, presented by Mr. J. Peacock; two Yellow-cheeked Amazons (*Chrysotis autumnalis*) from Honduras, two Wall Creepers (*Tichodromus muraria*), European, deposited.

OUR ASTRONOMICAL COLUMN.

DISTURBANCE OF CORONA IN NEIGHBOURHOOD OF PROMINENCES.—Prof. C. D. Perrine, who had charge of the expedition to Sumatra organised by the staff of the Lick Observatory to observe the total eclipse of the sun on May 18, 1901, gives in his report a preliminary description of the results obtained in the *Astrophysical Journal*, vol. xiv. pp. 349-359. From a short examination of the photographs of the corona obtained with the forty-foot and Floyd telescopes (which are stated to show the details of the inner corona very perfectly in spite of the presence of clouds during the exposure), there is distinct evidence of disturbances in certain areas of the coronal structure. Especially noticeable is a conspicuous series of coronal hoods surrounding a prominence in position angle 115°, and also an unusual appearance in the north-east quadrant of the corona. This latter is near position angle 65°. Close to this point on the limb there is a small compact prominence, surrounding which the disturbed area has a form roughly resembling an inverted cone of large angle. The apex of this area is not visible, appearing to lie below the chromospheric layer showing at the limb. From the apparent position of the apex, a number of irregular streamers and masses of matter radiate as if propelled by some explosive force. A long thread-like prominence to the south of this point appears to originate from the same source. Above and around this region the corona is composed of broken irregular masses, very similar to those depicted on the photographs of the Orion and other nebulæ.

A NEW SOLAR THEORY.[1]

IT is a remarkable fact that in the numerous theories which have been propounded in explanation of the periodic changes of the solar phenomena no account has yet been taken of so important an element as the light- and heat-absorbing envelope surrounding the photosphere. The attention which this so-called solar atmosphere has hitherto received, on the part even of our most eminent investigators, in connection with the economy of radiant energy on our luminary, is utterly disproportionate to the importance of the subject. In spite of the fact, which was first accurately established by Langley's observations and was afterwards confirmed by others, that the sun, if deprived suddenly of this protecting screen, would radiate into space as much as double its present amount of energy, solar physicists failed to perceive that changes in the absorptive power of this envelope must entail consequences of the most far-reaching character with respect to the thermal conditions on and in the sun. That such changes—and these, too, of no inconsiderable magnitude—must inevitably occur is a conclusion which it is hardly possible to evade when it is remembered that the supreme control over the dispensation of solar energy depends entirely on a thin, shallow surface-layer, the matter of which is constantly tossed about by vehement eruptions and acted upon by a most complicated and powerful system of convection currents to and from the sun's centre.

The possibility of variations of the opacity of the solar atmosphere was, it is true, strongly urged, more than twenty years ago, by one of the greatest authorities on this question. Shortly after his well-known researches into the absorbing faculty of the solar envelope, Langley pointed out the decisive influence on the sun's radiation into space caused by changes in the transmissive power of its atmosphere. But his attention was at the time solely directed towards their probable effects on the temperature of our own planet. He found that an increase of absorption by as much as 25 per cent. would diminish the mean surface temperature of our globe by 100° F., whilst a like diminution in the solar envelope would produce a corresponding change in the opposite direction.

Now if the influence of a change in the absorptive power of the solar atmosphere is so enormous on a planet at a distance of almost a hundred millions of miles, of what inconceivable importance must it not be for the sun itself? Drawing the very natural inference that a *deficit* of outside radiation means a *surplus* of energies working upon the solar matter, and *vice versâ*, we are forcibly led to conclude that even slight changes of opacity, such as would elude our most refined observations, are bound to greatly influence the state of thermal equilibrium on our luminary.

Hence, if changes in the absorptive power of the sun's atmosphere exist, as cannot but be the case, the question presents itself: What happens with those energies which, by a condensation of the solar envelope, are prevented from escaping into space? No doubt they are preserved to the sun, but in what form? Do they raise the temperature of the solar mass, or augment its store of potential energy, or have they a share in the generation of those marvellous dynamical displays which we perceive in periodic succession on the solar surface? Questions such as these must tend to convince the investigator that a research into the causes of the variability of the forces which we see acting on the sun, if not identical with, is at least closely akin to, the investigation of the origin and the physical properties of the sun's atmosphere. I shall endeavour, in these columns, to demonstrate the possibility of such changes in the density of the solar envelope as would lead to alterations of the thermal conditions of the sun's mass, and shall make an attempt to answer the question as to how far these changes must be conducive to variations in the dynamical phenomena at the sun's surface.

There is perfect unanimity amongst astronomers as regards the nature of the force which by a continuous generation of heat compensates for the loss of energy into space. Helmholtz's theory, which attributes this heat-generation to the progressive contraction of the solar mass as a consequence of gravitation, may be regarded as one of the most probable hypotheses ever propounded in the history of physical science. But this theory does not yet enable us to form an idea of the evolution of a celestial body. It explains the existence of a heat-generating force within the star's bulk, but it gives no answer to the question as to whether the loss of energy by radiation is exactly compensated for by the generation of energy through contraction, or whether the conditions of contraction peculiar to the sun may not perhaps produce *more* or *less* heat than is required for compensation. It is, indeed, inconceivable that the conditions of contraction can remain the same throughout the lifetime of a star. The spectroscope has revealed the fact that the photospheres of different stars exhibit widely different stages as regards temperature. There are doubtless suns hotter than ours, and others considerably cooler. And we may confidently assume that the various conditions of temperature now recognised in the different types of star-spectra represent the phases which successively appear in the evolution of each of these bodies from its origin as a far-extended nebula down to its complete obscuration. In the life of each of these stars there will be a period when its temperature is on the ascent, and when, consequently,

---

[1] Abstract of a paper in *Astr. Nachr.* (No. 3723-24): "Ueber eine neue Theorie zur Erklärung der Periodicität der solaren Erscheinungen."